Criteria for the Diploma qualifications in science at Advanced level

Principal learning

Date: March 2010
Product code: Ofqual/10/4721

Contents

Purpose

The purpose of this document is to record a full set of criteria for level 3 principal learning qualifications for the Advanced Diploma in science. It also sets out the overall aims of the Diplomas in science.[1]

This document should be read in conjunction with the Ofqual document *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990) at www.ofqual.gov.uk/files/OAC_diplomas_v2.pdf, which defines the overarching criteria for all Diplomas at Foundation, Higher and Advanced levels, and the *Line of learning statement in science* produced by the Diploma development partnership (DDP) representing the industries covered.

All references to guided learning hours (GLH) within this document are for the purposes of ensuring that at each level there is sufficient content specified to enable the design of qualifications. GLH are not intended to indicate final unit sizes or design.
The purpose of the line of learning criteria is twofold:

- to provide the regulatory tools (alongside the overarching criteria) that the regulators will use to accredit qualifications that are developed for the Diploma and to admit qualifications and/or units of accredited qualifications into the Diploma catalogue

- to specify the requirements against which awarding organisations will develop their principal learning qualifications for the Diploma.

[1] Principal learning is taken at level 1 for Foundation Diplomas, level 2 for Higher Diplomas and level 3 for Advanced Diplomas.

Aims

The general aims of the Diplomas are identified in Section 2 of the document *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990).

The purpose of the Diploma in science at Advanced level is to give learners an insight into how science is practised, and to understand its impact on society in the context of the major challenges of the 21st century. Through their studies learners will develop fundamental scientific and mathematical skills, knowledge and understanding that will enable them to tackle these challenges and related problems and questions with due consideration to social, moral, ethical and political issues and human and environmental consequences. This will include consideration of these major challenges from UK, European and international perspectives.

The Diploma in science at Advanced level will appeal particularly to those learners who:

- are interested to find out how people use science in their work and enjoy studying science as it is used in authentic contexts
- prefer an experiential approach to learning that involves extensive practical, experimental and investigative work
- want to study a broad spectrum of scientific ideas, concepts and practices
- see value in having a broad understanding of science at level 3 given the contribution of multidisciplinary teams to scientific developments.

Principal learning provides the essential knowledge, skills and understanding for all learners within the sector(s) covered. Additional and specialist learning enables learners to acquire a deeper understanding and/or application of the topics covered in principal learning or to explore a related topic with a more local focus.

Each Diploma in science will:

- enable individuals to acquire relevant personal, learning and thinking skills (PLTS) in a science context
- give opportunities to practise and acquire essential functional skills in English, mathematics and information and communication technology (ICT) that are relevant to the level and delivered in the context of science
- support progression to employment, science and science-related further and higher education courses, and a range of Advanced Apprenticeships such as laboratory technicians, pharmacy technicians and assistants, dental nursing, engineering technology and polymer processing
- aid effective transition to further education, work-based learning or higher education and to working life by providing a wide range of transferable skills and knowledge
- provide a motivating learning experience through a blend of general education and applied learning within a coherent and stimulating programme.

Vision

The purpose of the Diploma in science at Advanced level is to offer an alternative learning experience that has been developed to enthuse and engage those learners who will benefit from acquiring scientific knowledge in an applied and meaningful context. These learners will be motivated and gain skills and understanding through using practical activities for authentic purposes. Skills, knowledge and understanding acquired through the Diploma will equip learners for employment where science is used directly and for many other occupations where a scientific approach to aspects of the work would be of value, or for further study. Principal learning at Advanced level has been designed to provide a strongly contextual and investigative focus where learners will be able to use scientific methods to approach a series of different problems or questions in different contexts. Application of scientific methods throughout will be based on a sound understanding of underlying theoretical principles drawn from across the main scientific disciplines and mathematics.

The Diploma in science at Advanced level will achieve this by fostering imaginative and innovative approaches to teaching, learning and assessment. It will bring together learners, teachers and day-to-day practitioners to blend workplace technologies and practices with interactive, enquiry-based learning. During their studies, learners will acquire the tools that scientists and industries use in taking a multidisciplinary approach to the challenges, problems and questions facing humanity's continuing development into the 21st century.

The diploma in science offers:

- **authentic work-related learning**
- **a multidisciplinary approach to solving problems, reflecting how science is carried out in the real world**
- **a focus on practical and investigative work to develop scientific and mathematical skills**
- **innovative teaching, learning and assessment.**

Building on the vision for the Diploma at Foundation and Higher levels the Diploma in science at Advanced level builds on recent changes and innovations in science education and has a number of distinctive features:

Multidisciplinary approaches

Many challenges, problems and questions tackled by scientists require multidisciplinary approaches. The various scientific disciplines, together with mathematics, contribute in different but complementary ways. The Diploma in science at Advanced level will show how scientific knowledge and expertise is deployed within and across disciplinary boundaries to solve the most complex questions and challenges that confront us.

Individualised learning programmes

The structure of the Diploma in science at Advanced level allows learners to build on a core of science and mathematical skills, knowledge and understanding gained from principal learning. The choice of extended project, work experience and additional and specialist learning allows learners to personalise their Diploma in line with their progression aspirations while adding further depth or breadth to their programme. However, regardless of the choices made, principal learning will ensure learners acquire the essential skills, knowledge and understanding that employers and higher education institutions require.

A focus on investigative and practical work

The Diploma in science at Advanced level puts the acquisition of investigative and practical skills as a key focus. Learners will carry out laboratory and field-based work, understanding the rigorous scientific methods that underpin them including investigation design, analysis, critical evaluation of data and the development of scientific and mathematical models. At the same time learners will develop the personal, learning and higher-order thinking skills valued by employers and higher education.

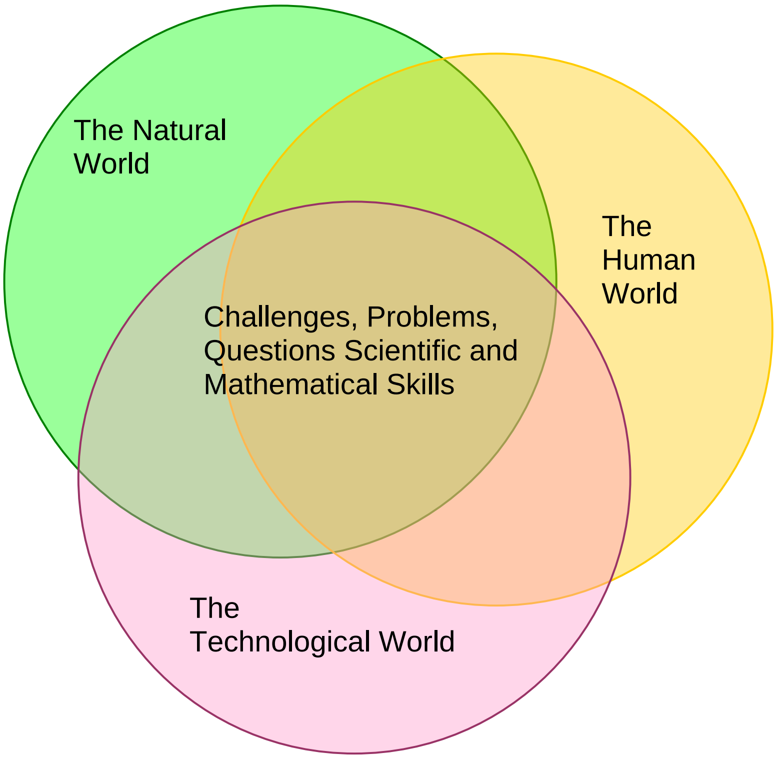
By applying these scientific methods to different kinds of challenges, problems or questions – without knowing the answers beforehand – learners will understand the principles of effective scientific investigation and be able to apply them creatively to new situations. Learners will come away with a set of transferable science skills valued equally by employers and higher education.

The Diploma in science at Advanced level seeks to:

- provide a solid base of scientific knowledge, understanding and methodology
- emphasise the importance of being able to transfer scientific skills, knowledge and understanding learned in one context to new situations
- engage and enthuse learners, extend their knowledge, understanding and capabilities, and raise their aspirations and ambitions
- provide insight into the application of science to real-life issues, including investigating natural behaviour, processes and phenomena; driving innovation and development, and improving the quality of life now and for generations; different ways in which scientific methods are used depending on the environment and sector
- provide an applied approach to acquiring scientific skills and knowledge, illustrating the benefits of scientific methods and their broader application to problem-solving
- ensure learners develop an appropriate understanding of mathematics and ICT that they are able to apply in scientific contexts.

Learners will create personalised learning programmes in line with their specific progression aspirations by choice of extended project, work experience and additional and specialist learning to complement the core of principal learning. The design of principal learning will allow learners to choose from a wide range of existing level 3 qualifications in science, mathematics and other disciplines as part of their own programmes.

Structure of the Diploma in science



We live and work in three interlocking worlds: the natural world, the human world and the technological world. At the centre are challenges, problems and questions to be tackled and the scientific and mathematical skills to do this. Effective deployment of these skills depends on knowledge and understanding of the underlying scientific and mathematical concepts, principles and techniques.

Structure of principal learning

The content of principal learning in the Diploma in science at Advanced level is driven by the scientific skills and knowledge needed to find potential solutions to challenges faced by humanity in the 21st century, including:

- providing adequate food and water supplies worldwide
- ensuring lifelong health and wellbeing for all
- meeting demands for energy and raw materials sustainably
- managing environmental change and biodiversity
- securing global stability
- harnessing emerging technologies.

These challenges have been derived from Grand Challenges identified by Research Councils UK, which have been taken up in different ways by individual research councils such as Biotechnology and Biological Sciences Research Council, Engineering and Physical Sciences Research Council, Natural Environment Research Council, Medical Research Council and Science and Technology Facilities Council. They resonate with Europe's Seventh Framework Programme for research and technology development (Cooperation within CORDIS FP7) in which themes include health; food, agriculture and fisheries, and biotechnology; nanosciences, nanotechnologies, materials and new production technologies; energy; environment (including climate change); and security.

However, challenges change over time. New ones emerge. Learners must be able to play their part in solving them. It is vital that they can transfer scientific skills, knowledge and understanding learned in one or more contexts to new situations. When asked to deal with an unfamiliar situation or problem, learners must be sufficiently well prepared to adapt readily and respond effectively.

The ability to operate confidently, effectively and safely in environments where science is used is central to this qualification. Through investigative approaches to key scientific principles learners will acquire essential laboratory and fieldwork skills, including handling and manipulating materials and equipment, data gathering (through observation and measurement) and recording, and be able to use these skills to tackle new or unfamiliar challenges.

The ability to plan, design, carry out and evaluate experiments that gather valid and reliable data to help resolve challenges, problems and questions, underpins all effective and credible scientific investigations. The nature of these investigations may vary from routine to complex. Across the principal learning, learners will experience increasingly complex investigations allowing them to apply their growing range of scientific skills and knowledge.

Opportunities to use analytical and critical thinking must be provided, including the application of mathematical concepts in scientific contexts.

Learners will need to understand that economic, environmental, ethical, political and social aspects need to be considered, as should psychological influences on data interpretation. They will be aware of the critical impact of ICT on the advancement of scientific practice and understanding.

The ability to communicate scientific ideas and findings clearly and appropriately is a critical skill for all scientists. Principal learning will provide a range of opportunities to present information in different formats for a variety of audiences.

To meet this vision for principal learning all specifications must:

- reflect the principal learning topics
- have links to major challenges
- demonstrate contributions made by different scientific disciplines to scientific understanding
- emphasise authentic workplace practices and provide opportunities for the development of relevant knowledge, understanding and skills as they relate to and support these practices
- have an applied purpose where learners draw on the knowledge, skills and understanding developed
    - allow sufficient time for:
    - the development of practical skills and their application in different situations and contexts
    - the development of mathematical knowledge, understanding and skills in units where they are most appropriate to the scientific contexts presented

  - reflection on the outcomes of own and others' investigations

- allow learners to draw upon their own practical experiences to propose solutions to problems or meet an applied purpose

- demonstrate the multidisciplinary nature of problem-solving in science.

Diversity and inclusion

Diplomas will enable all learners to be assessed by means of internal and external assessment, differentiating only on the basis of candidates' abilities to meet the assessment requirement. Diplomas will use plain language that is free from bias and there will be no covert or overt discrimination in wording or content. There must be fair and equal access to the Diploma for a diverse range of learners, so that all can benefit from the high-quality applied learning in employability skills, knowledge and understanding that it provides.

Component awarding bodies must design assessment requirements so that there are no barriers to achievement for disabled learners, unless the barrier is explicitly justified as a competency standard in line with the *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990). There must also be no barriers to achievement in the assessment requirements in terms of gender, race, age, sexual orientation and religion/belief.

The development of principal learning qualifications and all associated tasks of assessment, awarding and appeal must take into consideration the needs of all potential learners to ensure that there are no barriers in terms of disability, gender, race, age, sexual orientation and religion/belief. Awarding organisations should take steps to remove any barriers, particularly for learners with disabilities, and where required make reasonable adjustments. This includes the design of information and communication hardware and software, and the formatting of communication in hard copy or online.

Reasonable adjustments for learners with disabilities must be offered where these are still needed.

Reasonable adjustments should reflect the candidate's usual methods of working and not invalidate the competency standard of the assessment requirements.

Component awarding bodies may allow assessment in British Sign Language. Where more than one language is used, the awarding organisation must put adequate mechanisms in place to guarantee the consistency of assessment across the different languages.

To support the requirements above, Component awarding bodies must have procedures in place to ensure relevant staff and associates are trained in ensuring equality in the design, development and subject matter of qualifications, assessment and awarding procedures, language used in assessment and systems used to ensure consistency of standards across options, centres and time. They must also ensure that the centres they register do the same and use buildings that provide access for all candidates in accordance with equalities legislation.

The Diploma qualification must include the identification of opportunities, if appropriate to the subject or sector, for developing understanding of spiritual, moral, ethical, social, legislative, economic and cultural issues.

Notes

The six areas of diversity in law are disability, gender, race, age, sexual orientation and religion/belief. In addition Ofqual's regulation promotes equality and aims to eliminate discrimination in terms of disability, gender and race, in accordance with public sector equality duties.

Themes

The classification of topics under themes has not been specified by the science Diploma development partnership.

Structure

Structure of the Diploma in science	
Level	Advanced
Total GLH	1,080
Principal learning (GLH)	540
Generic learning (GLH)	180
Additional/specialist learning (GLH)	360

Principal learning level 3: Summary of topic titles

Topic no.	Title	GLH
3.1	Investigations, data and models	90
3.2	Mapping and monitoring earth's resources	60
3.3	Sourcing substances from biomass	60
3.4	Energy use in transport systems	60
3.5	Healthy people and the impact of environments on health	90
3.6	Designer molecules and materials	90
3.7	Detection, information transfer and analysis	90

Topic 3.1 Investigations, data and models (90 GLH)

All scientific enquiries require the application of rigorous scientific method. The selection of approaches, interpretation of findings and reflection on the outcomes of investigations enable scientists to improve their practice and add to our understanding of the natural, technological and human world.

Scientific method is applied across the full range of employment sectors in which science is used and also in other sectors that rely on the systematic, investigative approaches to solve problems and address challenges.

The purpose of this topic is to enable learners to demonstrate their grasp of the essential knowledge and skills that underpin all scientific investigations through the application of scientific method to a problem, challenge or question. They will have the opportunity to design, carry out and evaluate investigations and as a result will be able to operate confidently, effectively and safely in a range of environments where scientific enquiries take place. The role of scientific and mathematical models in describing and explaining observed phenomena will be explored and learners will be able to devise investigations that test existing models or develop new models. Through their experience of the design and evaluation of a range of scientific investigations learners will gain a sound knowledge and understanding of underlying scientific and mathematical concepts, principles and techniques, which they will be able to apply to new contexts and problems.

Learners must know and understand:

1. how investigations are used to create and test models, answer questions, respond to challenges and solve problems

2. the purpose of descriptive and explanatory scientific models

3. how scientific models are constructed and tested and the validity of their use in prediction

4. data collection and recording methods, including ICT, and their strengths, weaknesses, benefits and limitations

5. how to design an investigation to ensure data (including qualitative and quantitative) gathered are valid and reliable

6. how scientists collaborate within and across teams to maximise benefits of disciplinary expertise, share information and undertake peer review, respecting confidentiality and intellectual property rights

7. methods used to research and assess the relevance and reliability of data from secondary sources including how to recognise, acknowledge and minimise bias; ability to replicate published experiments

8. what good practice is in a range of environments in which scientific enquiries take place, including how to carry out a hazard or risk assessment and a knowledge of relevant legislation

9. procedures, equipment and materials for use in laboratory and fieldwork

10 numerical computation of data and relevant mathematical scientific notation

11 how to use statistical measures, diagrams and techniques in the interpretation and representation of data including correlation and regression

12. how to use algebraic and graphical techniques to analyse, make sense of and describe real situations

13. how to draw conclusions from data and assess their significance, including identification of errors and causes of uncertainty, and estimation of confidence level

14. how to evaluate the effectiveness of methods used and the validity of results obtained

15. how to report to a specific audience including choice of methods for presenting data, use of references and scientific terminology, supporting claims with scientific evidence and giving reasoned arguments

Learners must be able to:

1. plan a scientific investigation to seek a solution to a question or problem
2. select and justify methods to gather and record data
3. analyse and evaluate data
4. draw conclusions based on data and information
5. evaluate the methods used

6. report findings in a standard scientific format.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- reflective learners
- team workers
- self managers.

Topic 3.2 Mapping and monitoring Earth's resources (60 GLH)

Investigating why and how humans rely on Earth's resources and understanding why the impact of the use of those resources are key to meeting future demand for energy and raw materials. Science enables us to locate and to monitor these vital resources and can help in managing the environmental impact of human activity.

People and organisations undertaking mapping and monitoring activities include geoscientists and geologists, mining engineers, metallurgists, oil and gas geologists, geophysicists and environmental geologists. Scientists who are particularly engaged in monitoring biodiversity include ecologists and environmental scientists.

The purpose of this topic is for learners to plan, research, investigate, map and survey different environments to locate and quantify raw materials and living organisms for specified purposes. Learners will carry out field work and secondary research, gathering data about biodiversity and the distribution of resources found in Earth's four spheres. They will select and use relevant scientific techniques and tools, justifying choices made to gather this data and learn approaches to monitoring these resources over time. Learners will know and understand the duties humans have to use these resources responsibly with due regard for political, social, environmental, ethical and economic considerations.

This topic could provide an opportunity for learners to work in teams.

Learners must know and understand:

1. geophysical techniques used for collecting survey data including ground penetrating radar, electrical resistivity, aerial photography and GPS imaging

2. geological tools and field equipment used for collecting survey data including those for surface and borehole sampling and sub-surface drilling

3. geochemical techniques used for analysing materials including for pH soil and water analysis, conductivity, chemical composition and spectrometry

4. types of information gathered by using geophysical and geochemical techniques and geological tools and field equipment

5. types of naturally occurring chemical compounds

6. models of atomic structure including electronic configurations

7. International Union of Pure and Applied Chemistry (IUPAC) nomenclature of organic and inorganic chemical substances and chemical formulae

8. the elemental composition of chemical compounds from the periodic table of elements and their structures including hydrocarbons and inorganic compounds

9. methods for species identification, naming and classification of fungi, plants and animals

10. factors affecting habitats including climate, weather, food availability, mates, territories, disease, water availability, inter- and intra-specific competition and predation

11. measures of biodiversity including total species number, indicator species, biodiversity hotspots, endemic and migrant species and genetic biodiversity

12. the roles of adaptation and natural selection in the process of evolution and their contribution to genetic diversity

13. implications of techniques and approaches to mapping and monitoring of environments and resources

14. analysis including chemical, biological, mathematical and statistical to determine the potential for exploitation of a natural resource

15. political, social, environmental, ethical and economic implications of the exploitation of a natural resource

Learners must be able to:

1. select and use appropriate surveying techniques and equipment to map an environment

2. gather data from an environment

3. analyse results from a mapping exercise

4. use diagrams to represent statistical information

5. present outcomes using scientific language and terminology.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- effective participators.

Topic 3.3 Sourcing substances from biomass (60 GLH)

Biomass has always been a crucial source of materials, particularly for food supplies, but also for fibres, medicines, dyes and pigments. As our understanding of the biochemistry and molecular biology of all organisms has developed it has become possible to apply increasingly sophisticated scientific approaches to obtaining and processing biomass. If we are going to be able to provide adequate food and water supplies worldwide and meet demand for energy and raw materials sustainably, we need to be able to maximise the potential for sourcing substances from biomass, including the potential to develop alternative fuel supplies and chemical feedstocks.

A wide range of occupations is involved in obtaining and processing biomass, including agricultural scientists, horticulturists, biotechnologists, botanists and chemists. They work in research and development (R&D) departments, manufacturing plants and in analytical quality control laboratories.

The purpose of this topic is for learners to apply their knowledge of the structure, function and reproduction of living organisms to assess and evaluate the potential of types of biomass. Learners will be able to identify organisms as potential sources and, at a micro scale, carry out processes to extract biomass substances. They will be able to justify the techniques, methods, equipment and materials used. Based on an understanding of the challenges involved in working with substances obtained from living organisms learners will be able to assess the technical, economical, environmental, social and ethical implications for scaling up their practical work to a commercial scale.

This topic could provide an opportunity for learners to work in teams.

This topic links to 3.2 and 3.6.

Learners must know and understand:

1. characteristics and features of healthy cells, tissues and structures in plants and animals
2. the potential of biomass as a source of materials with useful characteristics
3. naturally occurring factors that affect the growth of organisms including light, nutrients, weather and climate
4. factors that contribute to optimising yields including control of pathogens, fertilisers, pest and disease control, patterns of inheritance, selective breeding, hereditary conditions, in-breeding and out-breeding, and genetic modification
5. techniques for monitoring growing environments and options for remedial action including identification and prevention of diseases
6. the challenges of commercial production of biomass including techniques and implications of processing
7. the scientific basis of techniques and processes to obtain products from biomass
8. types of storage, packaging and preservations used for products from biomass including use of smart materials
9. environmental, legal, political, social and ethical requirements associated with the production and retailing of products from biomass.

Learners must be able to:

1. assess the potential of animal and plant growth programmes as a source of biomass
2. select relevant extraction and processing techniques to create products from biomass
3. analyse and characterise products obtained from biomass
4. evaluate the implications of industrial scale production of a product from biomass
5. present a case for or against industrial scale production of a product from biomass.

In order to engage with this topic effectively, learners must use the following PLTS:

- effective participators
- creative thinkers
- reflective learners
- self managers.

Topic 3.4 Energy use in transport systems (60 GLH)

Movement from place to place requires energy. Humans are unique in creating a multitude of ways to improve their ability to move from place to place. Society depends on many forms of transport, often over large distances, for access to food supplies, essential services and for leisure activities. Transport systems rely on infrastructure as well as vehicles. They are complex and place high demands on energy resources and other raw materials. Their design and management can be modelled to take account of logistical challenges and human behaviour. Reduction of energy balanced with safety and reliability will contribute to more efficient and sustainable transport systems.

People and organisations involved in harnessing new technologies to improve transport systems include industrial laboratories and design departments, university research departments and a wide range of scientists, technologists, engineers and mathematicians working in both the public and the private sectors.

The purpose of this topic is to allow learners to apply their understanding of the way in which scientific principles are used in the design and implementation of transport systems. Learners will study the mechanics of movement including resistive forces, and propulsion systems. Through exploring the factors that affect the efficiency and safety of transport systems, including human behaviour, they will have the opportunity to analyse data from a range of sources and be able to propose and test improvements.

This topic could provide an opportunity for learners to work in teams.

Learners must know and understand:

1. the principles of kinematics and dynamics applied to transport systems

2. how mechanical energy is generated in modes of transport (land, water and air) including electric motors and internal and external combustion engines

3. how science is used to improve efficiencies and increase safety in transport systems including maximising capacity, infrastructure design, the reduction of fuel demand, improved engine and transmission technologies, and materials design

4. how ICT is used to support the design of safe, efficient and effective transport systems

5. the impact of human behaviour on the design of safe and effective transport systems

6. the relationship between energy resources required for transport systems and overall energy consumption and balancing supplies with demand

7. quantification of energy consumption and calculation of the efficiency of energy transfer

8. developments in cells (including chemical and batteries, fuel cells, nuclear batteries and photovoltaic cells, energy inputs and outputs and efficiency) and techniques to determine their performance characteristics

9. techniques for assessing the impact of design and construction changes on safety and efficiency in transport systems including modelling techniques that take account of patterns of use.

Learners must be able to:

1. use secondary sources to explore the limitations of aspects of transport systems and their impact on safety and efficiency

2. propose an improvement to an aspect of a transport system

3. design an investigation of a proposed improvement

4. carry out an investigation of a proposed improvement

5. evaluate the limitations of the investigation.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- creative thinkers.

Topic 3.5 Healthy people and the impact of environments on health (90 GLH)

Understanding the characteristics of healthy human beings, including their behaviour, and an appreciation of how these are affected by their environments is essential to the planning of effective health care programmes. The nature of health care programmes varies globally and will be influenced by political, economic and social conditions.

Those involved in planning and delivering health care programmes include doctors and nurses, backed up by teams that include healthcare scientists, radiotherapists, health visitors, midwives, physiotherapists, medical physicists, dieticians and community health practitioners. People involved in the diagnosis of diseases include clinicians and pathologists. Many people are involved in establishing and maintaining healthy living environments, including scientists, architects, town planners and environmental health officers.

The purpose of this topic is for learners to be able to apply their knowledge and understanding of the functions of a healthy body and factors that have an impact on health and wellbeing to propose and evaluate intervention options and preventative measures. They will have the opportunity to analyse diagnostic data and draw conclusions from it. Learners will find out how improved hygiene, nutrition and health care, together with an understanding of the importance of the design and maintenance of living environments, can contribute to people being healthier and living longer. Learners will have the opportunity to model trends to help them anticipate occurrences and predict the potential spread of disease.

This topic could provide an opportunity for learners to work in teams.

Learners must know and understand:

1. basic processes in human cells and an appreciation of the physiology of the main organ systems of a healthy body including the characteristic features of healthy cells, tissues, organs and organ systems in humans

2. natural changes to the body as it ages and different models of ageing

3. types of diseases and the changes they cause to the human body and mental health of individuals, including diseases or genetic conditions that compromise the healthy functioning of the body

4. the relationship between brain and behaviour, including brain structures underlying the basic functions of behaviour

5. types of medical and surgical treatment options

6. preventative medicine options including vaccination, health education and screening programmes, and their effectiveness in ensuring lifelong health and wellbeing

7. methods to obtain, analyse and interpret diagnostic data, including models to predict patterns and spread of diseases

8. the concept of health and wellbeing in human beings

9. the subjective nature of health including an awareness of health on an individual and societal level and World Health Organisation definitions of these

10. how the living environment impacts on the perception and expectations of health

11. the concept of environmental health and factors that affect the quality of human living environments

12. techniques of monitoring and intervention to reduce or eliminate environmental and social factors that might affect human health and wellbeing

13 social, ethical, political, cultural and economic considerations that may impact on the choice of treatment, intervention or environmental design options

14. how to present treatment, intervention or environmental design options to a given audience.

Learners must be able to:

1. analyse and evaluate observational data relating to health and wellbeing

2. present reasons for observed effects of the environment on health and wellbeing

3. recommend a solution to an environmental challenge to health and wellbeing based on scientific understanding

4. use scientific principles to justify the programme designed / actions proposed to solve a challenge to health and wellbeing.

In order to engage with this topic effectively, learners must use the following PLTS:

- creative thinkers
- effective participators.

Topic 3.6 Designer molecules and materials (90 GLH)

By applying scientific concepts, principles and models it is possible to make a vast range of chemical compounds, formulations and materials that affect the quality of our lives. The design and manufacture of new molecular compounds and materials will contribute to all of the challenges concerning humanity’s continued development.

New molecular compounds and materials are designed and produced by preparative or synthetic chemists, formulation chemists, materials scientists and technologists, metallurgists, biologists and analytical scientists. Places of work include research and development (R&D) departments, manufacturing plants and analytical, materials testing and quality control laboratories.

The purpose of this topic is for learners to devise and follow processes to make products with particular characteristics. These products could be molecular compounds or new/modified materials. Learners will gain an understanding of the relationship between the structure and bonding of molecular compounds and their properties (biological, chemical and physical). Learners will then be able to determine physical properties of materials, and relate them to potential uses. They will also have an opportunity to consider the ethics surrounding the development and introduction of new materials.

This topic could provide an opportunity for learners to work in teams.

This topic links to 3.3.

Learners must know and understand:

1. the classification of organic compounds and functional groups (including aliphatic and aromatic hydrocarbons, alcohols, phenols, carboxylic acids, esters, aldehydes, ketones, amines, amides and halogenocompounds), chemical formulae (empirical, molecular, structural and displayed) and types of chemical reaction and reaction types (including addition, elimination, substitution, oxidation and reduction)

2. structures of molecular compounds, polymers, metals and ceramics

3. types of bonding including molecular shapes and crystal structures, and models of ionic, covalent and metallic bonding

4. how the design and effectiveness of new compounds and materials are influenced by the relationship between physical and chemical properties, intended uses of compounds and materials, structures of compounds and materials, and bonding of compounds and materials

5. enthalpy changes, reaction kinetics and dynamic equilibrium including factors that affect reaction rates and yield of products

6. techniques for synthesising molecular compounds, including separation, purification, determination of yield and analysis to determine purity

7. how to calculate theoretical and percentage yield and purity using amount of substance, and the mole

8. how physical properties of materials in the laboratory are determined, including practical testing, reference to secondary source databases and calculations

9. how to interpret information provided by techniques used to investigate the structure of a compound or material, including mass spectrometry, nuclear magnetic resonance spectroscopy, infrared spectroscopy and X-ray crystallography

10. techniques used in the context of molecular synthesis to increase the sustainable use of resources, manage waste and recycle materials including green chemistry and atom economy

11. economic and environmental considerations in the production, preparation or modification of a compound or material, including waste management.

Learners must be able to:

1. use sources of information to establish the relationship between properties, uses and structure of a product

2. propose a synthetic route for a product based on information about structure, properties and use

3. review a proposed synthetic route to determine its validity in synthesising a product

4. synthesise and purify a product

5. evaluate the effectiveness of the synthesis process.

In order to engage with this topic effectively, learners must use the following PLTS:

- independent enquirers
- self-managers
- reflective learners.

Topic 3.7 Detection, information transfer and analysis (90 GLH)

Scientists use a wide range of devices for detection and analysis. Each of these devices has a particular function and works best in a given situation. Such devices rely on the application of key scientific principles and it is important that learners understand these principles. This understanding helps learners to assess the usefulness of a device in a particular context. Only by understanding the scientific principles that underpin how a device works, and the related strengths and limitations of the device, can learners make judgements about the quality of data collected.

Scientific devices are used and developed by those working in industrial laboratories and university research departments. They are used by environmental and health scientists, geoscientists, medical physicists, analytical and forensic scientists and scientific service providers. For example public analysts use flame and atomic absorption spectrophotometers to carry out trace element analyses in occupational and environmental samples, including workplace monitoring and the detection of air pollution and water pollution.

The purpose of this topic is for learners to apply their knowledge to make and test electrical and electronic devices for detection and analysis. In order to do so learners must understand the scientific principles involved in detection by a device and the transfer of information within the device. Information transfer will usually also involve transformation into a form that can be analysed. Learners will understand the nature of electrical conduction and the use of the electromagnetic spectrum in transferring and analysing information. They will also understand the purpose of electrical components incorporated in devices for detection, information transfer and analysis. In making and testing devices, learners will justify choices made and also compare and contrast the performance of their devices to commercially available products. They will also assess the cost and suitability of their device compared to those used in industry. Learners will understand the situations in which such devices are used, and how they function and are powered.

This topic could provide an opportunity for learners to work in teams.

Learners must know and understand:

1. situations in which detection, transfer of information and analysis is required
2. principles, applications and limitations of electrical measurements for the purpose of detection or analysis
3. modelling electrical systems using mathematical equations
4. the nature and properties of the electromagnetic spectrum, including wave properties and the relationship between wavelength, frequency and energy *($\lambda = c/v$ and $E = hv$)*
5. the role and purpose of sensors, transducers and actuators
6. the principles and applications of imaging techniques, including diffraction, wavelength and resolution
7. low and high resolution mass spectrometry principles and applications, including fragmentation patterns and parent ions
8. spectroscopic principles and analytical applications, including quantisation of energy and photon energy
9. limitations of imaging techniques, mass spectrometry and spectroscopy
10. factors influencing the quality of the information detected and analysed
11. the role and purpose of a transmitter, the transmission medium and a receiver in an information transfer system

12. how information is transferred via optical fibres, radio waves and microwaves including the use of photons, total internal reflection, critical angle, bandwidth, attenuation and polarisation

13. applications, performance characteristics and limitations of information transfer systems.

Learners must be able to:

1. design and make an electronic/electrical device for a specific detection and/or analysis purpose

2. justify scientific design features of the device to a specified audience

3. measure and analyse performance characteristics of electrical/electronic devices

4. assess capabilities, limitations and potential applications of such devices

In order to engage with this topic effectively, learners must use the following PLTS:

- reflective learners
- self managers.

Personal, learning and thinking skills

Awarding organisations must design learning outcomes and assessment criteria that clearly include opportunities for the development of PLTS. At all levels of the Diploma principal learning must include all six PLTS. These should be integrated as a minimum within the assessment criteria for principal learning to explicitly recognise the application of these skills within sector-relevant contexts.

Awarding organisations must also provide a clear mapping of the coverage of PLTS within their submission. This should be at the level requested under each topic within the criteria, such as ‘independent enquirers’, ‘creative thinkers’ and so on.

Functional skills

Components and qualifications based on these criteria must provide opportunities for learners to develop and apply functional skills within sector-specific contexts. Awarding organisations must provide a summary of the appropriate opportunities identified.

Additional and specialist learning

Please refer to the Ofqual document *Criteria for accreditation of Foundation, Higher and Advanced Diploma qualifications* (Ofqual/08/3990) at www.ofqual.gov.uk/files/OAC_diplomas_v2.pdf for the rules governing additional and specialist learning.

Advanced level: External assessment

At Advanced level, the principal learning will have 180 GLH of external assessment.

Ofqual wishes to make its publications widely accessible. Please contact us if you have any specific accessibility requirements.

First published by The Office of Qualifications and Examinations Regulation in 2010.

© Qualifications and Curriculum Authority 2010

Ofqual is part of the Qualifications and Curriculum Authority (QCA). QCA is an exempt charity under Schedule 2 of the Charities Act 1993.

Office of Qualifications and Examinations Regulation
Spring Place
Coventry Business Park
Herald Avenue
Coventry CV5 6UB

Telephone 0300 303 3344
Textphone 0300 303 3345
Helpline 0300 303 3346

www.ofqual.gov.uk